Monster Redshift Surveys through Slitless Imaging

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Photo credit: Chris Schur

The idea

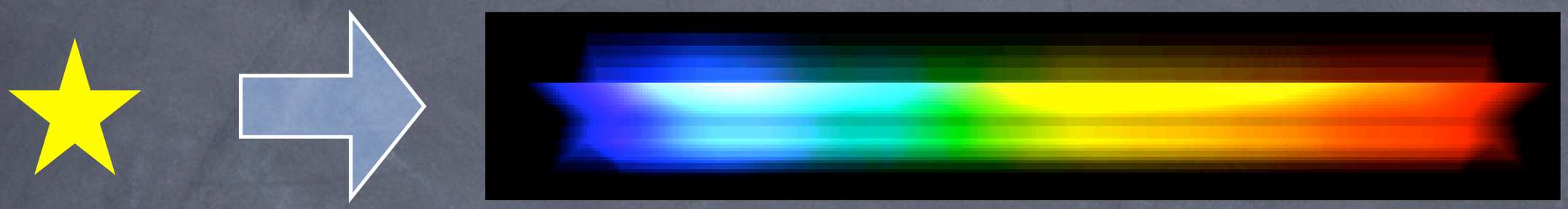
- Low NIR 1-2μm background in space
- High line luminosities z>1 objects

- Efficient spectroscopy/redshifts with small telescope and slitless grism
- WF 1m/0.5° FOV telescope ~ 10^8 objects 1<z<2 over 10^4 deg^2

Science

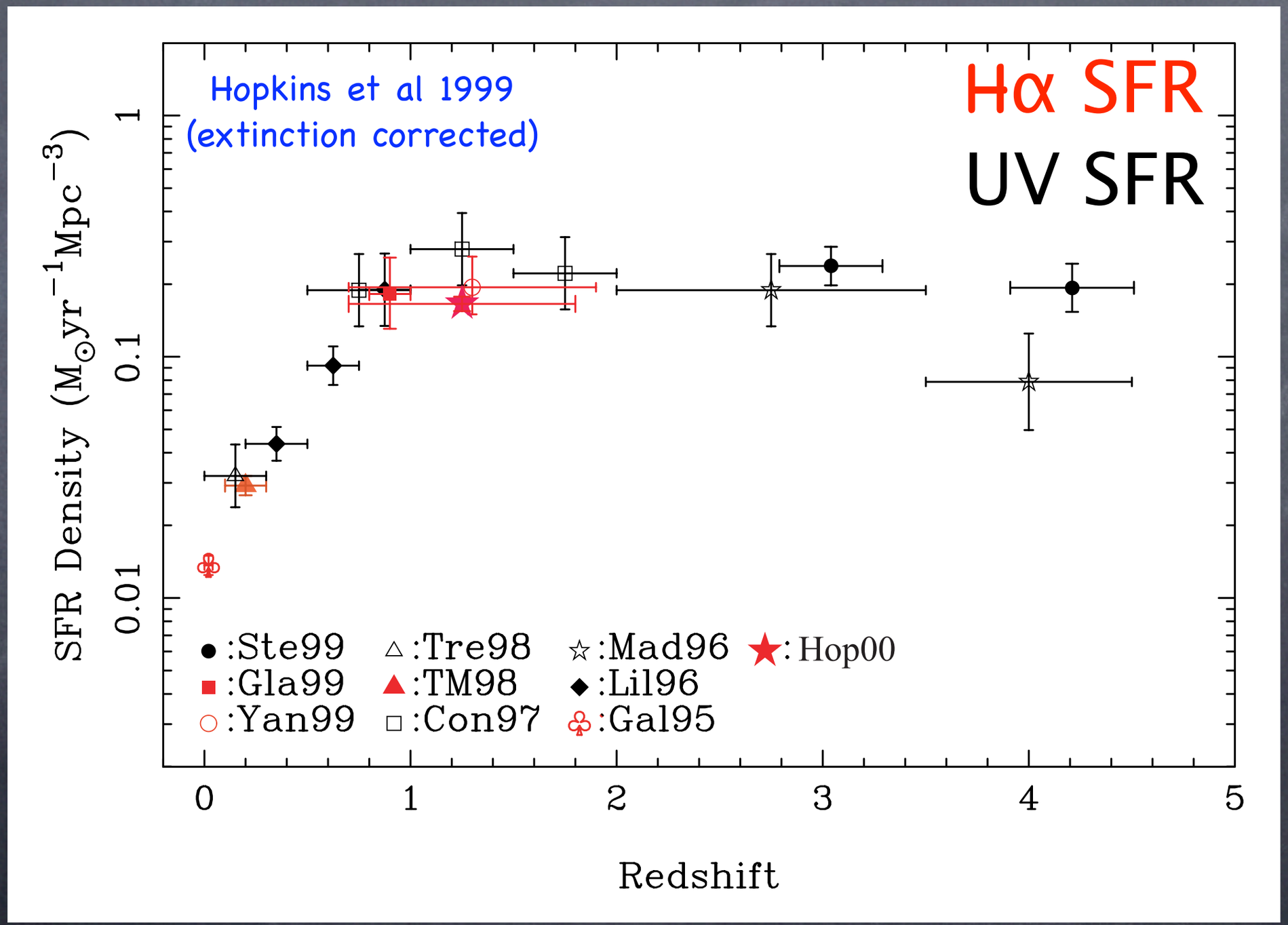
- Dark energy w(z) via baryon P(k) oscillations
- z>1 galaxy clusters - 3D detection
- Evolution of Galaxy clustering/galaxy evolution
- Luminosity function, metallicity and environment
- Depth information for lensing studies
- Direct WF Lyα searches 7<z<15 DARK AGES

Slitless primer

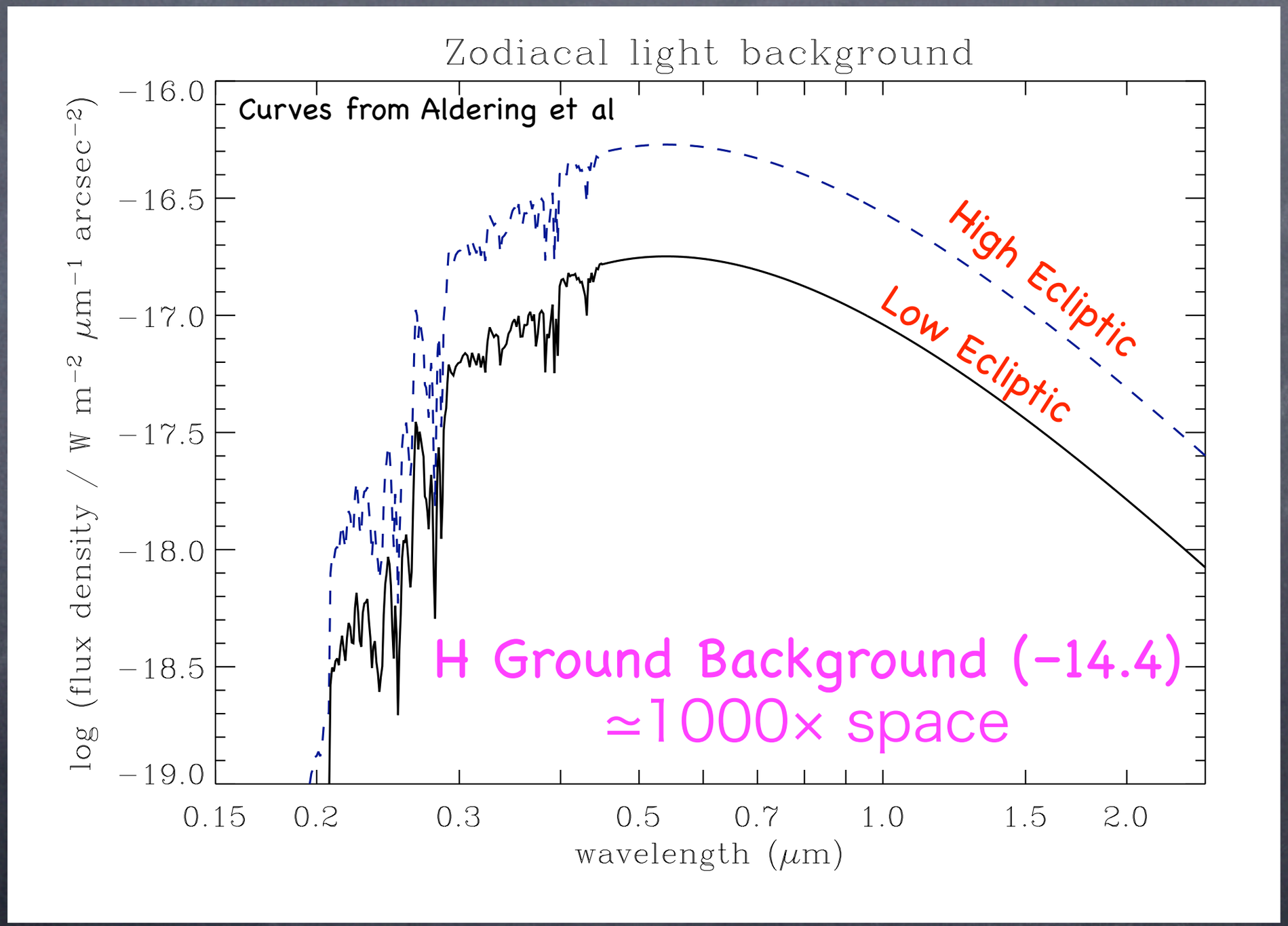


- Grism disperses full image
- Object forms it's own slit
- Background (per pixel) UNCHANGED defined by blocking filter (e.g. J, H)
- S/N (un-resolved emission line) indpt of $R=\lambda/\Delta\lambda$

Why it's Easy: I

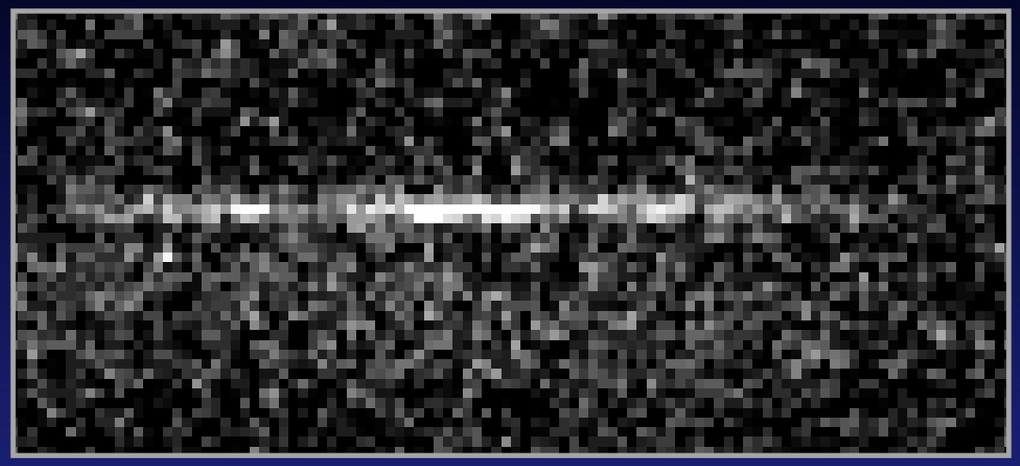


Why it's Easy: II



Slide courtesy of Adam Riess

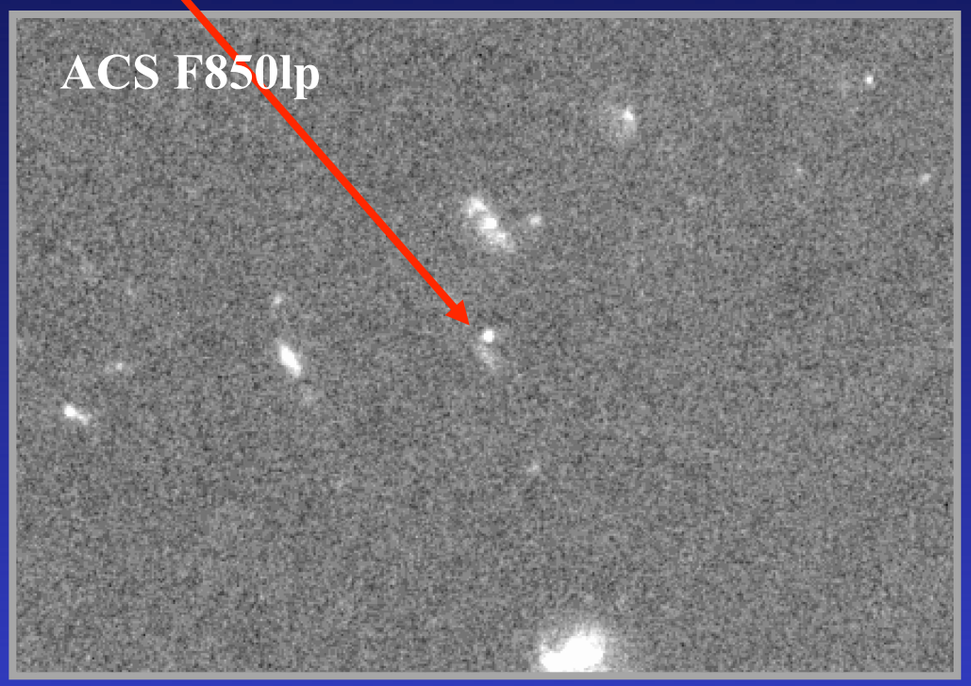
GOODS: first higher-z SN Ia, Aphrodite

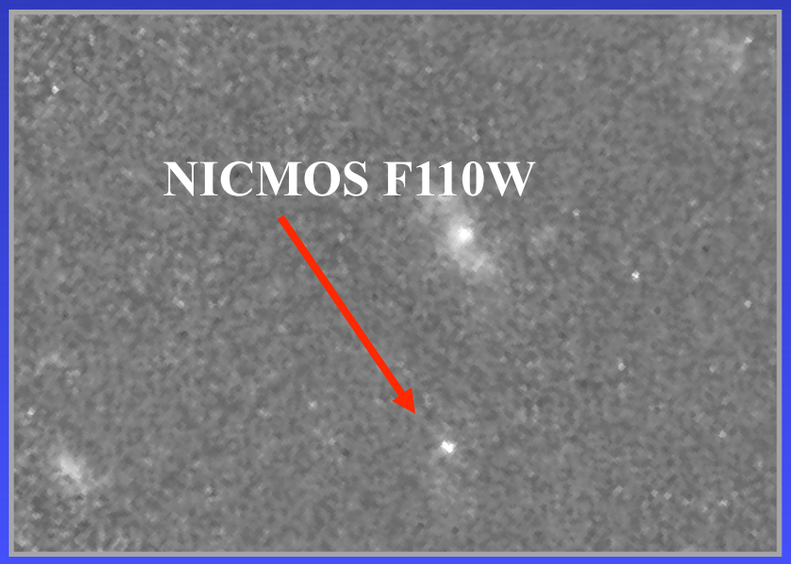


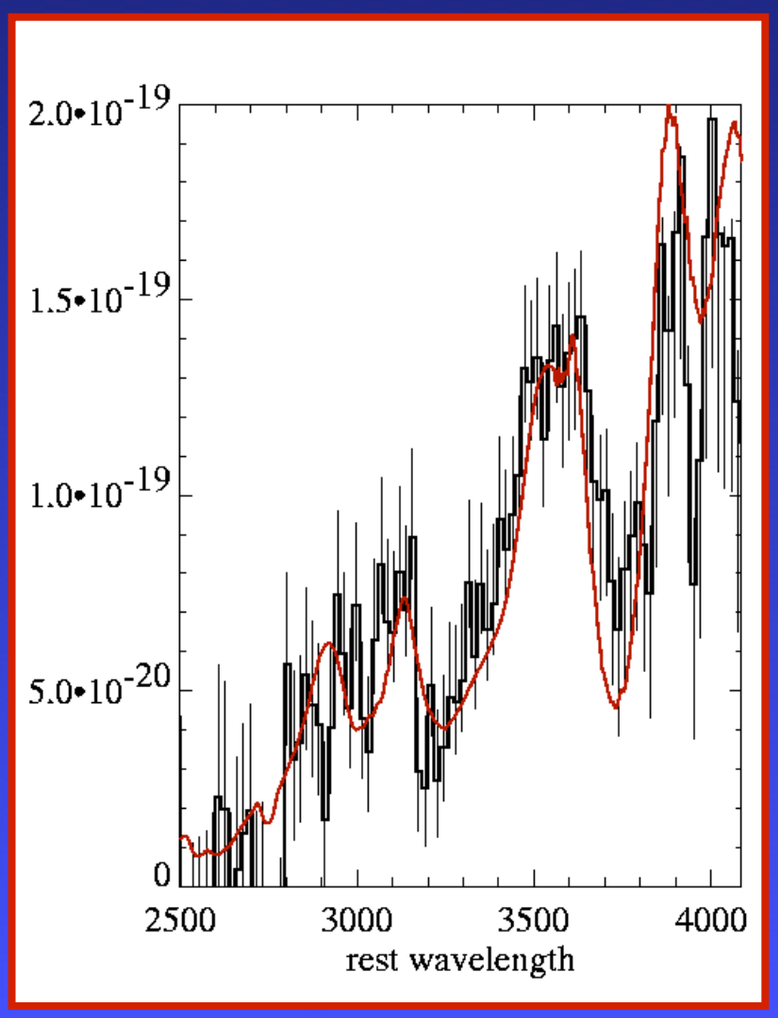
ACS grism spectrum

Highest z spectrum of a SN

Aphrodite (z=1.3)

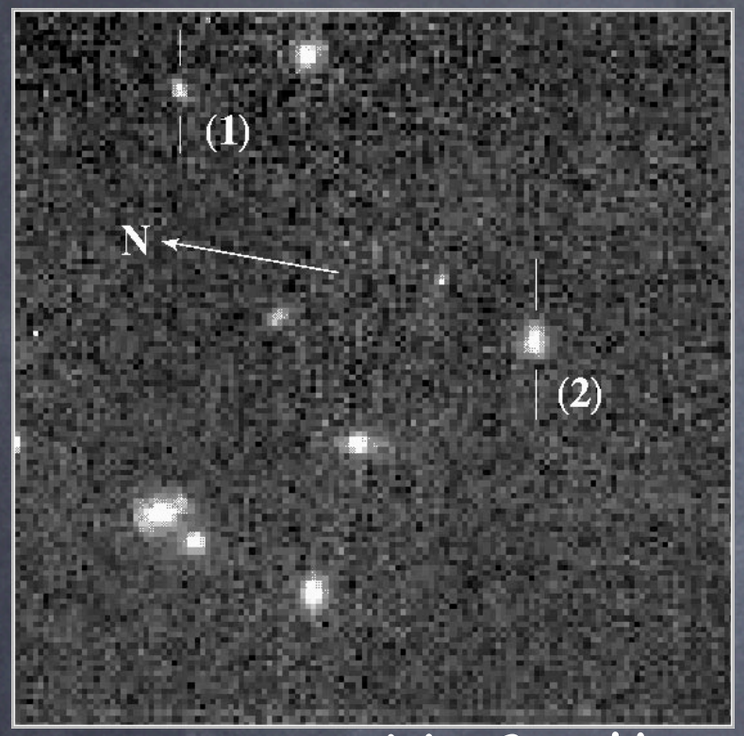


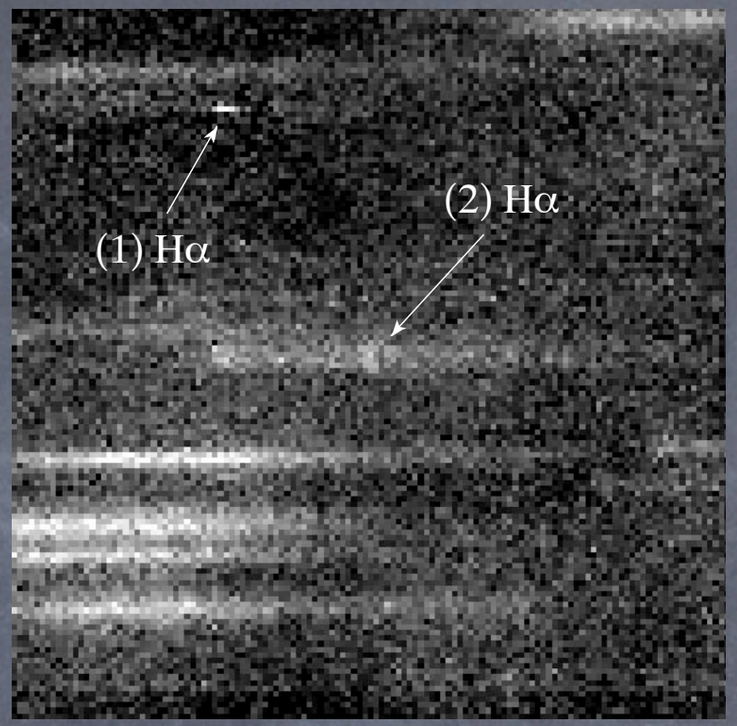


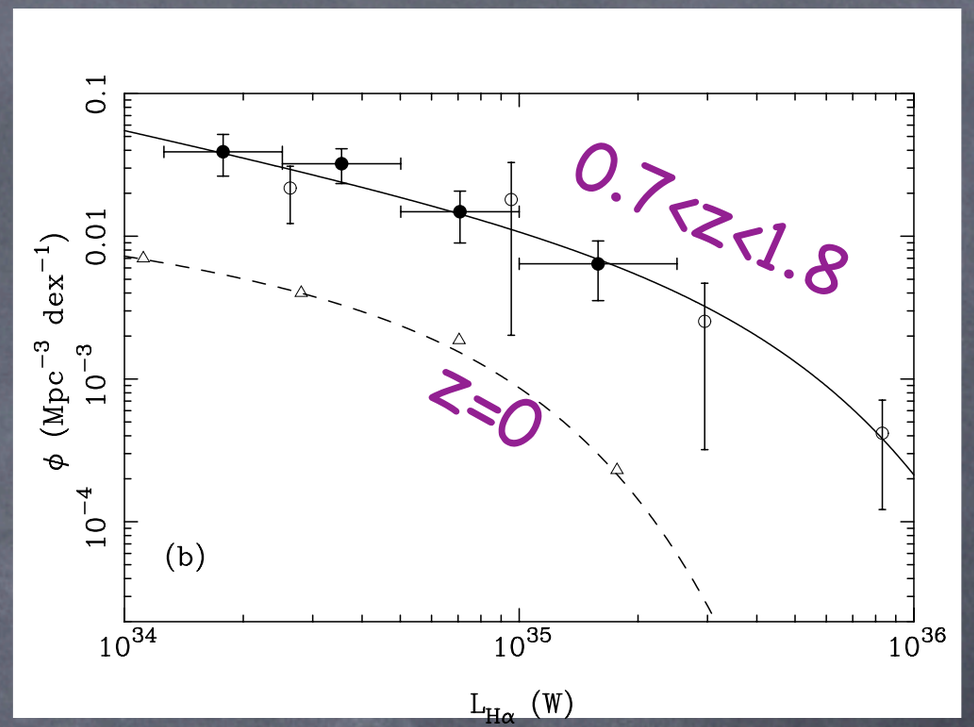


NICMOS slitless surveys

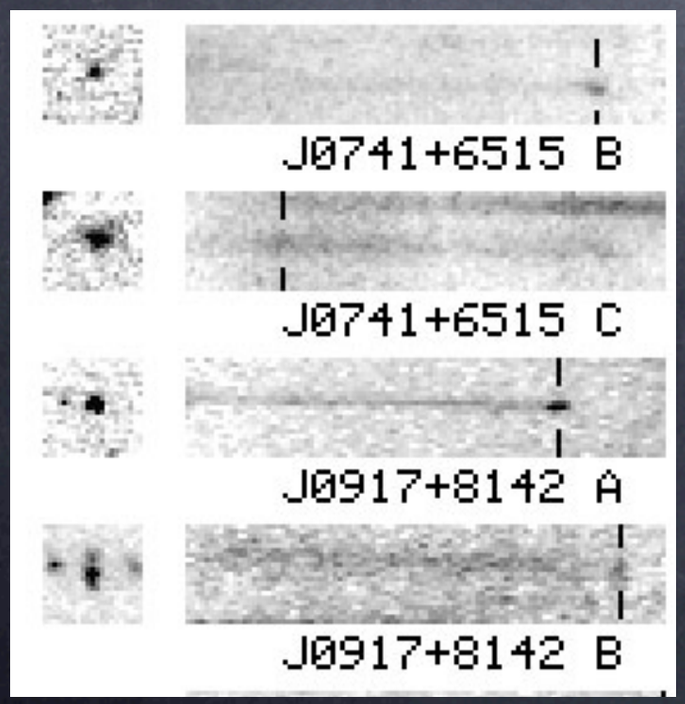
Hopkins et al. (2000)

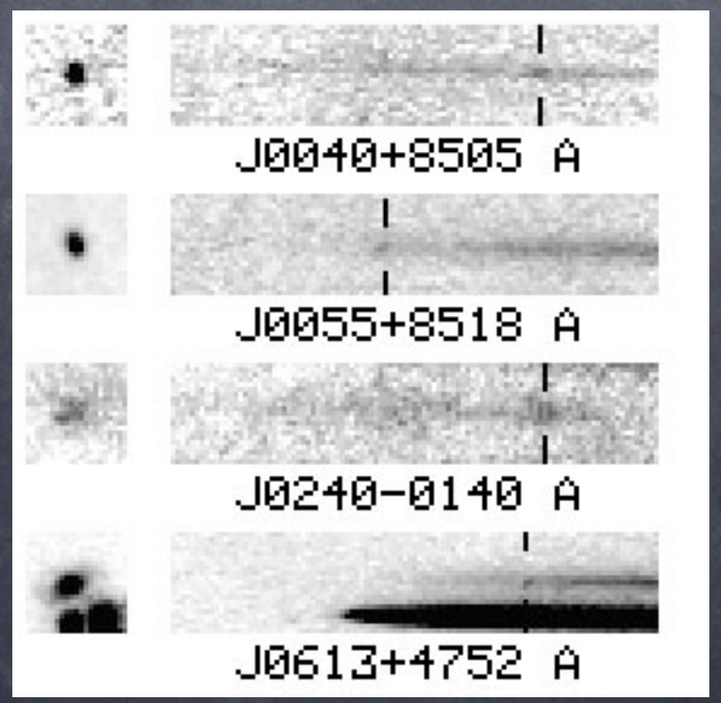






McCarthy et al. (1999)



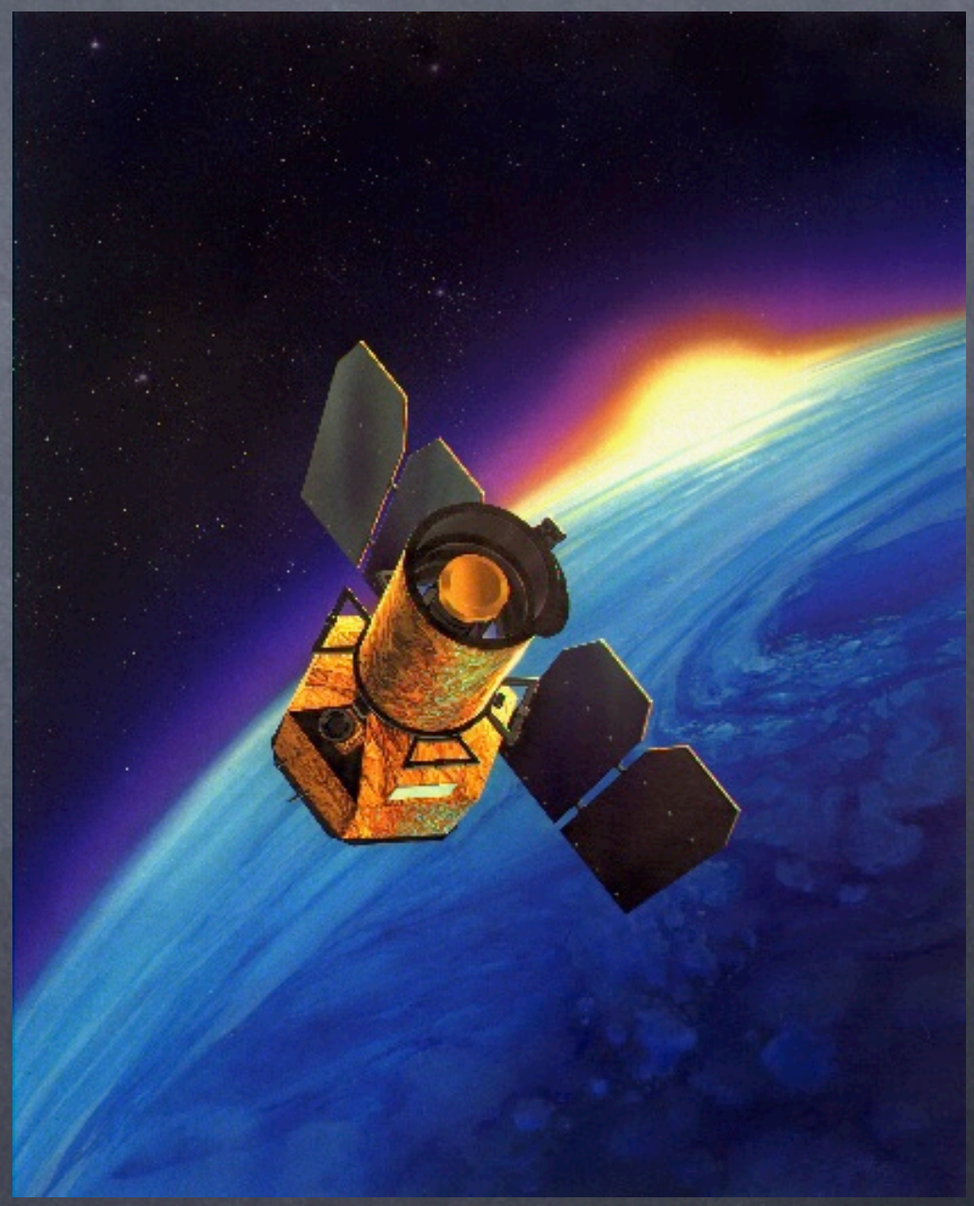


≧70% are genuine Hα (confirmed Keck [OII] det.)

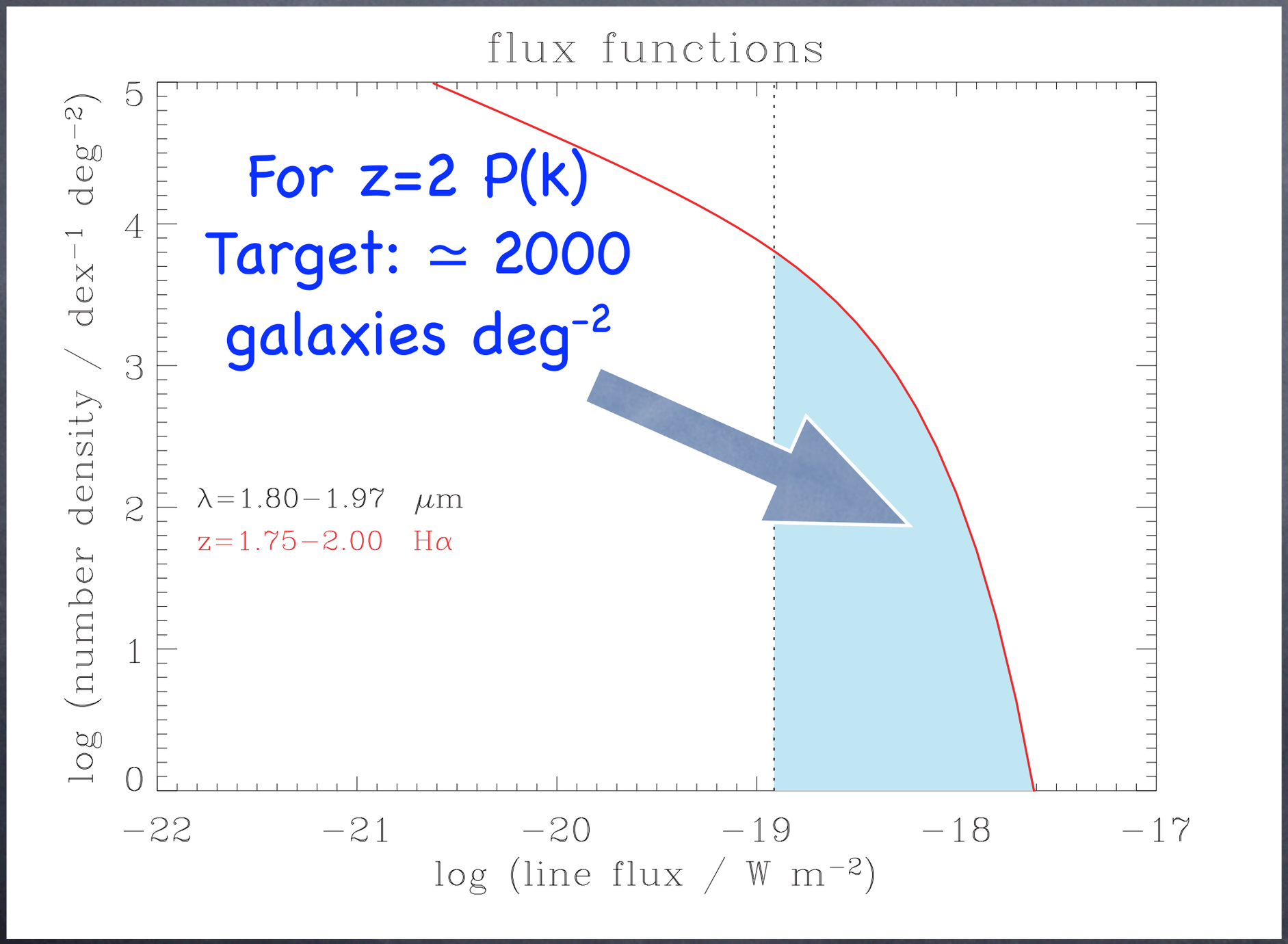
Strawman Mission

"Baryon Oscillation Probe"

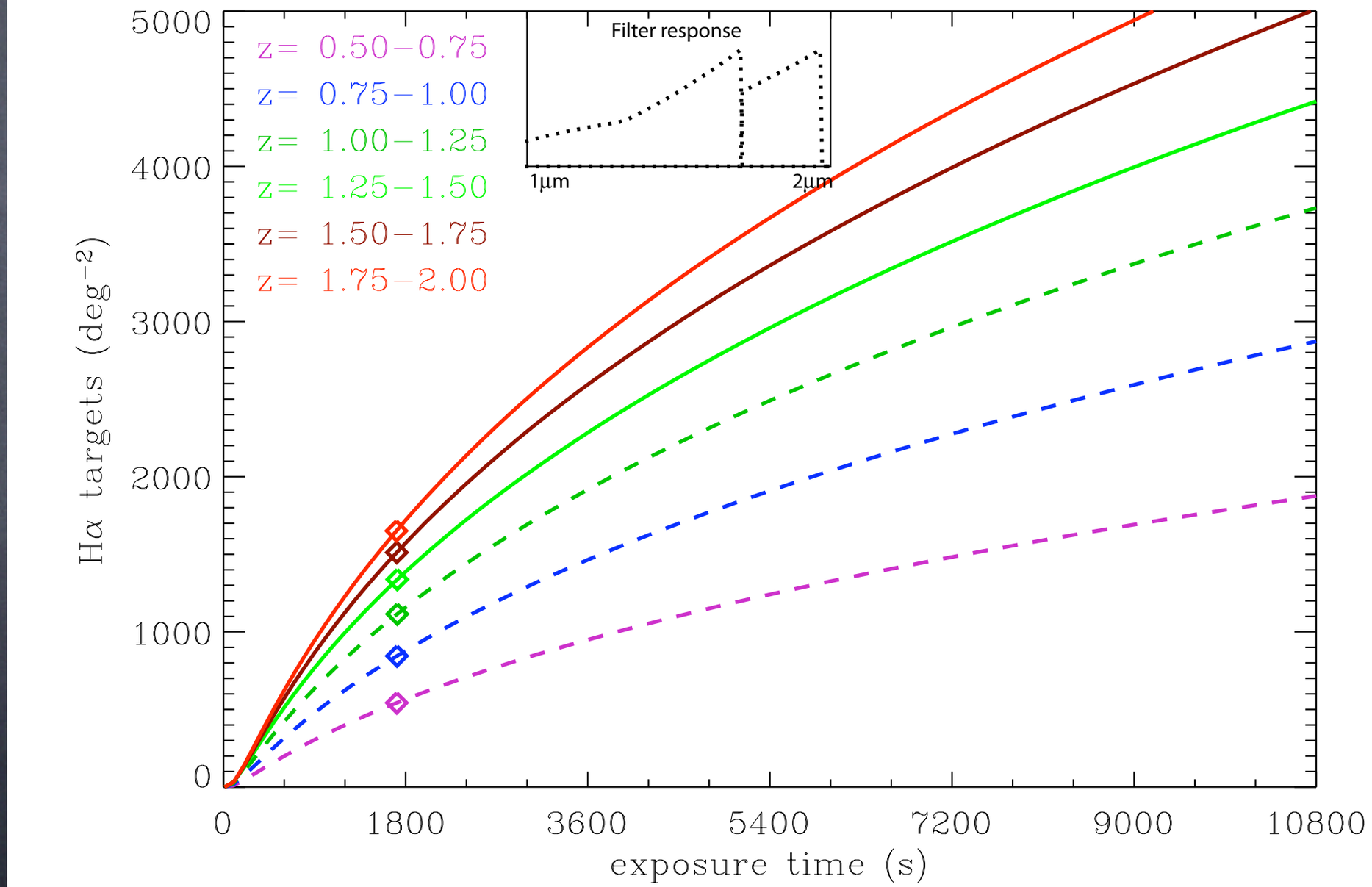
- 1m Telescope
- 25% throughput 1-2μm
- 0.5° diameter FOV
- 1 arcsec resolution
  ($4K^2$ pixel requirement)
- size/mass/cost ≈ MIDEX



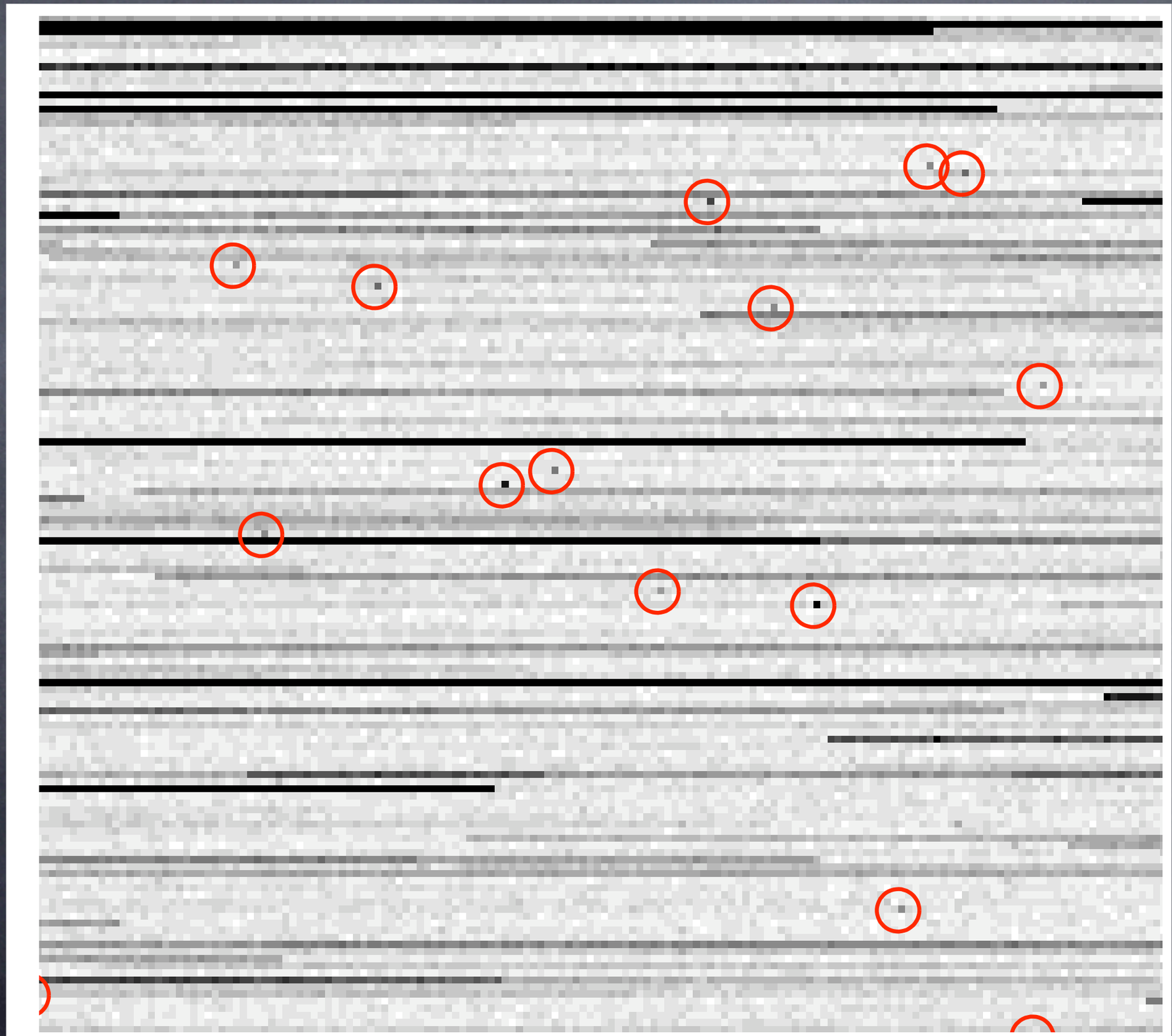
Number counts



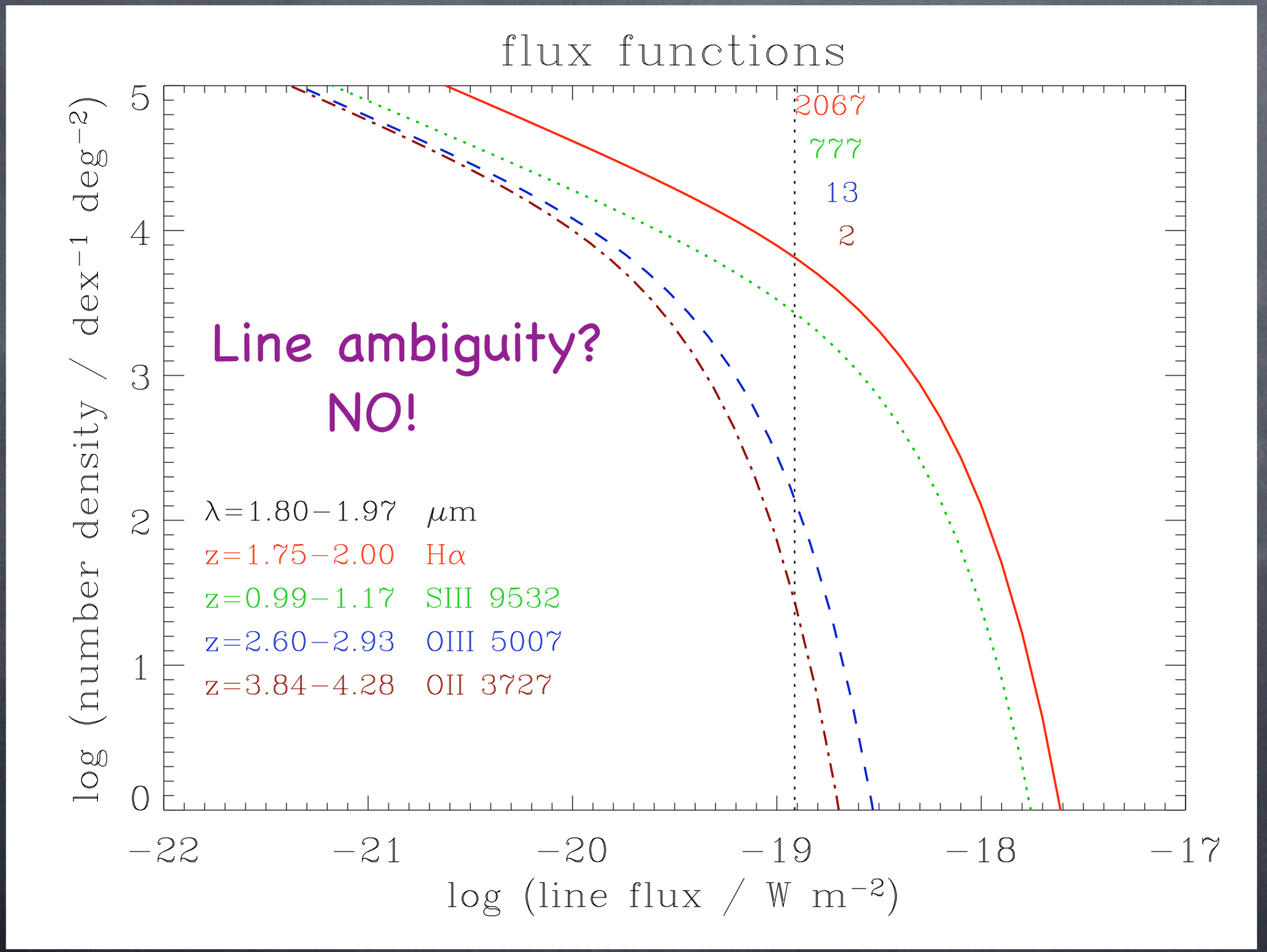
Exposure times



Toy Simulation



Issues -I


flux functions
2067
777
13
2
Line ambiguity?
NO!
λ=1.80−1.97 μm
z=1.75−2.00 Hα
z=0.99−1.17 SIII 9532
z=2.60−2.93 OIII 5007
z=3.84−4.28 OII 3727
log (number density / dex^{-1} deg^{-2})
log (line flux / W m^{-2})
0
1
2
3
4
5
−22
−21
−20
−19
−18
−17

Issues - II

- Resolution. R=700, $\Delta z = 0.004$ (for 1 arcsec object) easy with grism (or objective prism?)
- Spectrum overlap: of order 5-10%.
  Need multiple roll angles
- Lyα (UV-optical) vs Hα (NIR)
  Exposures 10-20× longer
- Number of filters.
  2 is probably best for shallow survey

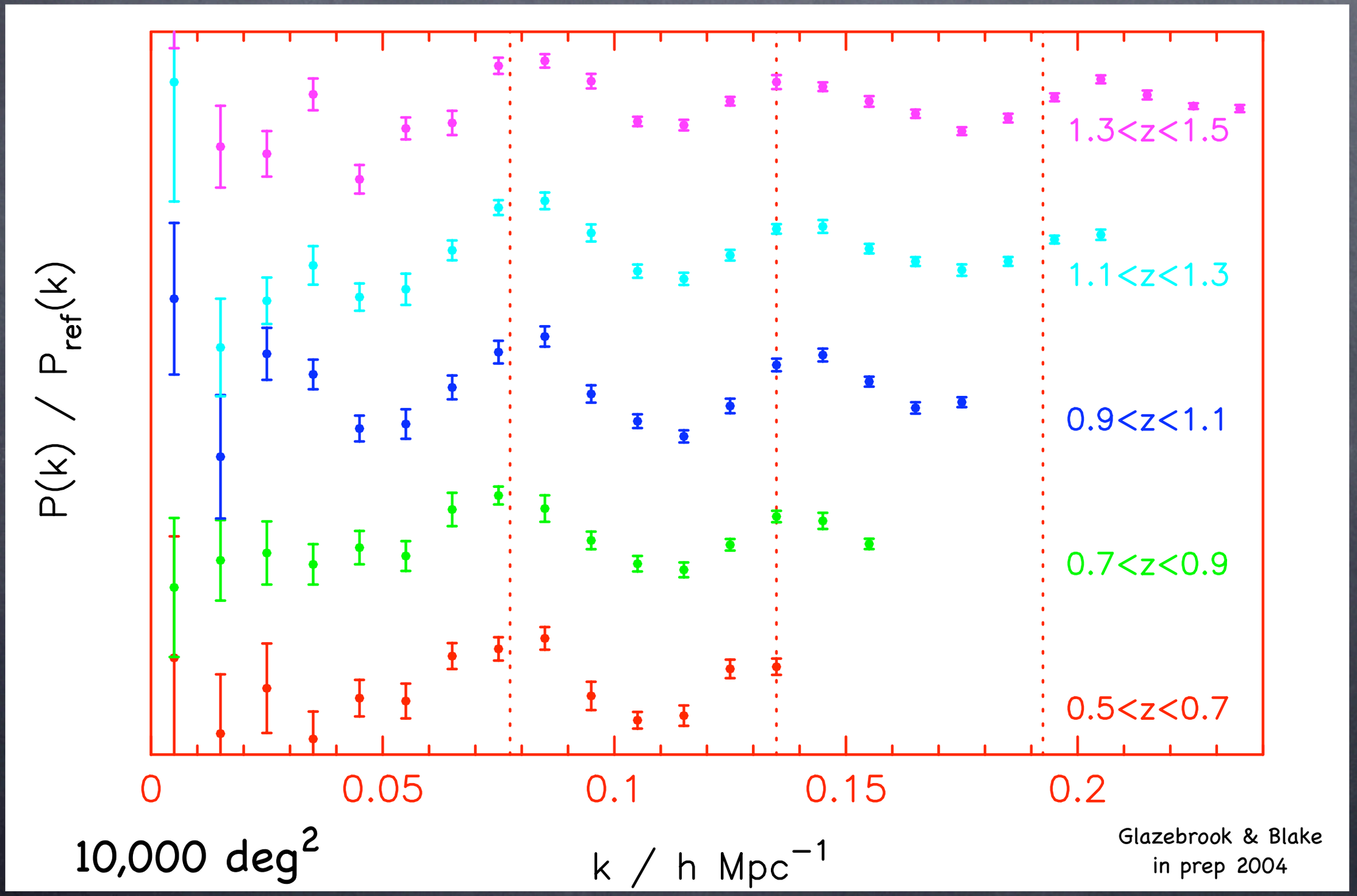
Redshift Survey Power

0.5<z<2

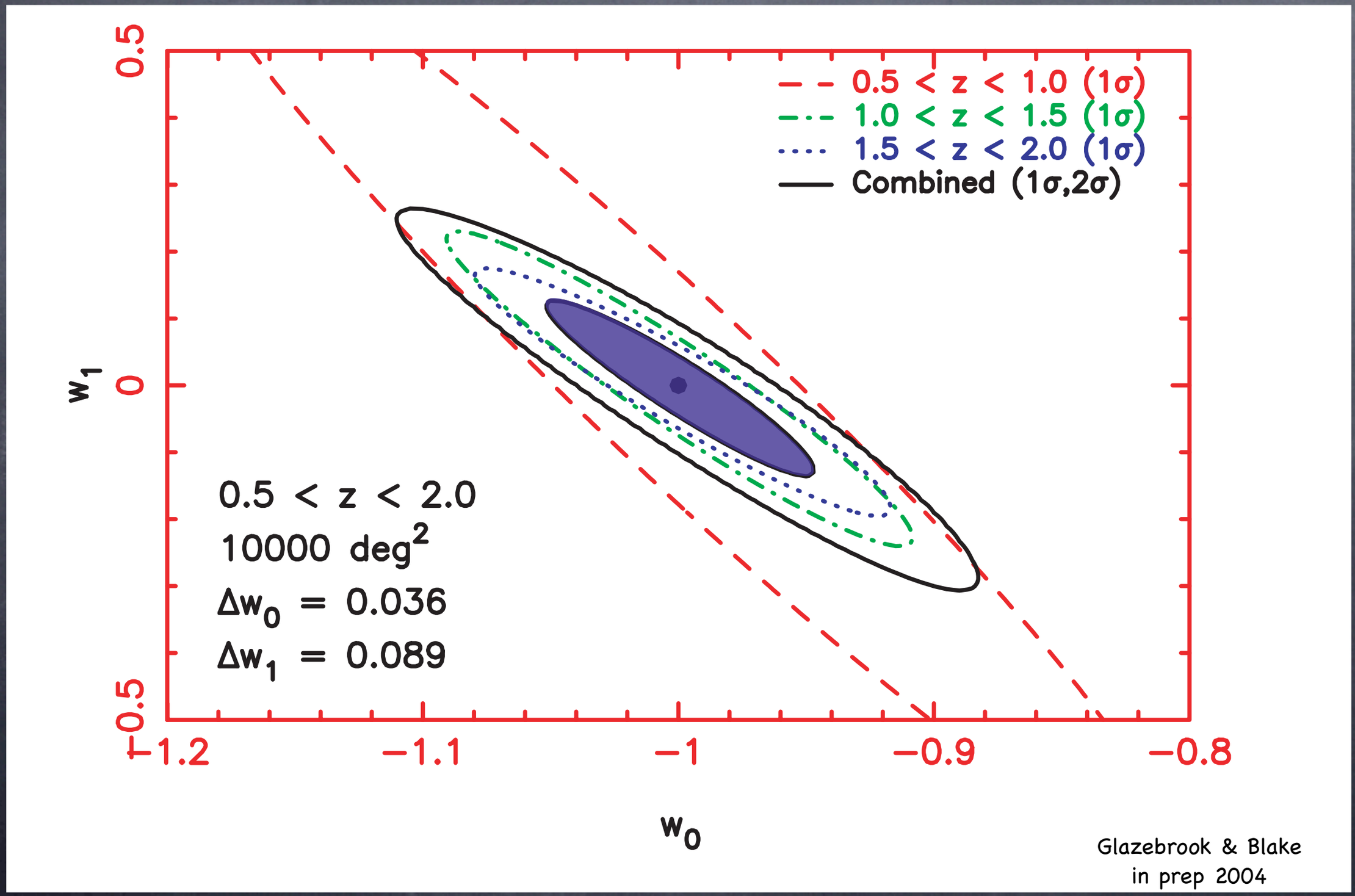
- 1m telescope, 0.5° FOV, 2 filters
  "Baryon Oscillation Probe"
  2000 deg^2 per year
  10^7 objects per year

- 2m telescope, 0.11 deg^2 FOV, 2 filters
  ("SNAP extra")
  3000 deg^2 per year

Example: Baryon wiggles P(k)



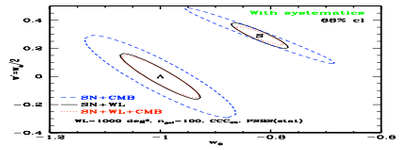
Baryon wiggles w(z)



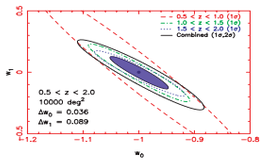
Riess et al 2004

Gold+Silver

Predicted SNAP
(Linder et al. 2004)



Predicted Baryon wiggles
10000 deg^2
(Glazebrook & Blake 2004)



68%
90%
95%

Ω_M=0.27+/-0.04

w'

8
6
4
2
0
-2

-3
-2
-1
0

w_0

Take home messages

- Simple, slitless grism surveys from space are surprisingly efficient redshift machines
- Emission line Hα redshifts $0.5<z<2$ 1-2μm
  10,000 deg^2 $1<z<2$ in 3-5 years with 1m telescope
- Any WF imaging mission (esp. dark energy!) should consider a grism component
- Removes the follow-up bugbear - get 3rd dimension from same hardware
- $(\Delta w_0, \Delta w_1)$ from Baryon Wiggles ≦ SNe in same scope of mission.